STRUCTURES DESIGN MANUAL
TABLE OF CONTENTS:

SECTION 14 – MINOR STRUCTURES

14. MINOR STRUCTURES

[Future Addition]

14.1 DRAINAGE STRUCTURES (CULVERTS & BURIED STRUCTURES)

[Future Addition]

14.2 OVERHEAD SIGN SUPPORTS

This manual describes the procedures to be used to design and detail sign structures in the State of Utah. Use these procedures for the design of all overhead sign structures.

Overhead signs include signs over any portion of the roadway, including the shoulders, requiring vertical clearance for vehicles to pass underneath. Overhead signs are used to provide the traveling public with clear messages under a variety of conditions, directly over the roadway.

The MUTCD contains the requirements for determining when and where overhead signs are required. Typically, overhead signs are supported by sign structures.

The MUTCD continues to be the authoritative source in determining what signs are necessary and where they are to be located. Ground mounted signs may be considered in lieu of overhead signs, if permitted by the MUTCD. In all instances, signs should be placed in a manner that will minimize potential danger and confusion caused by motorist uncertainty.

This manual does not include design guidance for protection of sign structures as fixed objects, determining the location and type of signs to be supported by the structure, or determining whether or not an overhead sign structure is needed in lieu of a ground mounted sign. Consult *the* Utah Department of Transportation *Roadway Design Manual of Instructions* and the *Manual of Uniform Traffic Control Devices*. All signs proposed for sign structures are subject to approval through UDOT Traffic and Safety Division.

14.2.1 GENERAL

Generally, there are four types of overhead sign supports used in Utah: (1) Cantilever, (2) Butterfly, (3) Span-type, and (4) Variable Message Signs (VMS). These sign types are shown schematically, in Figure 1. VMS supports are always full-span type. The Traffic & Safety Engineer typically determines the required size and location of signs and if an overhead sign is required. All overhead sign structures are tubular steel structures.

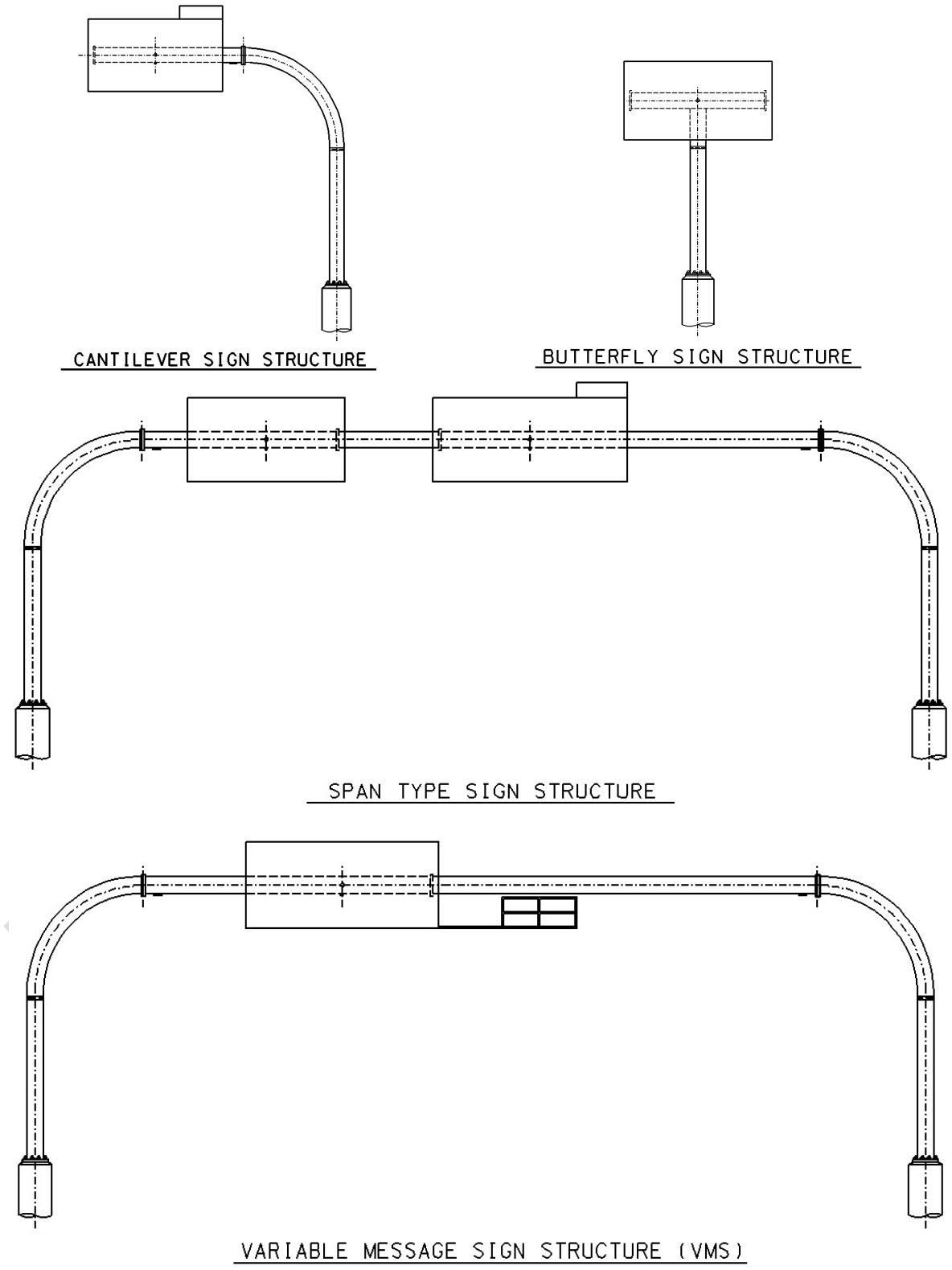


Figure 14.2.1-1 Overhead Sign Structure Types

When an overhead sign is needed, select the proper means of support. The following is basic guidance for typical circumstances and is not intended to be comprehensive.

1. Do not locate signs on bridge structures without prior approval from UDOT Structures Division.

2. Avoid using sign structure supports to span both directions of a divided highway to support signs intended for only one direction. Instead, use a structure spanning one direction with a median support, or use a cantilever, depending on the sign location. (Note: A median support foundation will involve a special design if it is located within a barrier. In other cases it may require protection as a fixed object; see Utah Department of Transportation Roadway Design Manual of Instructions.)

   A sign structure spanning two traffic directions of an interstate or divided highway will generally be more costly than an equivalent one direction structure due to its greater length and required section. Additionally, a structure spanning two traffic directions will be more costly to inspect and cause twice the traffic disruption and potential hazard compared to an equivalent one direction structure.

3. Cantilever structures are typically the most appropriate solution to support signs over the shoulder and/or the travel lane nearest the post. Long arm cantilevers will generally be more costly than equivalent spans and are subjected to much greater fatigue loads than full sign bridge structures. Cantilevers with shorter arms for signs over the shoulder or travel lane nearest the post will generally be less costly to construct and inspect than full sign bridges. In certain cases, two small cantilevers may be considered in lieu of full sign bridge spanning two directions, depending on site specific conditions.

4. Avoid placing an overhead sign structure on a bridge when the signage is intended for the over roadway. This type of structure requires specially designed post supports and connections. In addition, bridge vibrations may affect the overhead structure. If there is no alternative to an overhead structure on a bridge, use a full sign bridge in lieu of a cantilever. Avoid use of cantilever sign structures supported on bridges.

5. Use a sign bridge structure to support Variable Message Signs (VMS) due to the eccentricity of the VMS dead load, the magnitude of fatigue forces and the potential for out of plane bending.

6. Use a span-type overhead sign support when the span of a cantilever sign support would exceed 42’-6. Span to height ratios greater than 1.5 may appear out of proportion and provide excessive movement due to wind loads. Therefore, when cantilever sign supports would exceed these limits, use full-span supports.

The UDOT Structures Division has developed standard designs and standard working plans for overhead sign structures to expedite the development of overhead sign structure plans. Sign structures that do not fit within the limitations of the standard designs require a custom design.

Provide a custom design for sign structures supporting walkways or VMS in accordance with the design criteria in Section 14.2.2.

14.2.2 DESIGN REQUIREMENTS

Design structural supports for overhead signs in accordance with the following requirements. These design requirements are general to all overhead sign supports. Design requirements specific to one type of overhead sign support are included in the section for that support type.

A. DESIGN SPECIFICATIONS

Design all structural supports for overhead signs in accordance with AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals,* 4th Edition.

B. LOADS AND LOADINGS

- Determine loads on sign structures based on the methodology described in the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*, 2001 with Interims to 2003
- Use 50 year service life
- Wind Load

  Standard designs are based on a basic wind speed (V) of 100 mph with a gust factor of 1.14. For custom designs, use basic wind speed (V) of 90 mph or as approved by the Deputy Bridge Engineer for Design. Adjust wind speed for special conditions as specified in Section 3.8.2.2 of the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*, when local conditions exist that would generate wind speeds exceeding 100 mph.
- Ice and Snow Loads = 3.0 psf
- Live Load

  No live load has been used in the design of the standard structures. No walkways or service platforms are included on the standard structures.
- Dead Load
  - Steel: 490 pcf
  - Sign panels, including attachments: 12 psf without lighting or 15 psf with lighting
  - Concrete in foundation design: 150 pcf
  - Soil in foundation design: 120 pcf
- Design all overhead sign structures for fatigue using Fatigue Category I.

C. MATERIALS

- Use monotube steel members hot-dipped galvanized according to UDOT Standards. Post and beams will meet the requirements of ASTM A53, Grade B, or API-5L-X42, modified according to UDOT Standard Specifications.

- Welding will comply with AWS D1.1 Structural Welding Code – Steel.
- Use full-penetration butt welds for shop splices. Use full-penetration shop butt welds for post to base plate connection.
- Other shapes and plates will meet the requirements of AASHTO M270, Grade 36 (ASTM A709, Grade 36), and will be hot-dip galvanized in accordance with AASHTO M111 (ASTM A123M).
- Make all connections with high-strength bolts conforming to AASHTO M164 (ASTM A325). Nuts and washers will meet the requirements of AASHTO M291 (ASTM A563) and AASHTO M293 (ASTM F436), respectively. Galvanize all sign connection hardware for cantilever sign in accordance with AASHTO M232 (ASTM A153).
- Use anchor bolts meeting the requirements of AASHTO M314, Grade 55 (ASTM F1554 grade 55). Galvanize in accordance with AASHTO M232 (ASTM A153).

D. MINIMUM CLEARANCES AND GEOMETRY

- Provide a minimum vertical clearance of 17’-6 ft between any and all elements of any cantilever sign structure and any point along the roadway cross-section beneath the structure.
- Interstate: Protect the foundations of all cantilever sign structure supports with concrete barrier or guardrail.
- Non-Interstate: Protect sign foundations with barrier or place outside of the roadway clear zone.
- Locate the sign foundation 4’-0 behind the barrier (measured from the front face of the barrier to the face of the foundation).

E. FOUNDATIONS

- Use drilled shaft foundations. These foundation loads represent the loads resulting from the maximum moments and shears of each combination of arm length and sign size.
- Geotechnical Design
  - Analyze drilled shaft foundations for lateral resistance and overturning using the p-y analysis method and using a program such as L-Pile or equivalent.
    a. Use ½-inch for the maximum lateral deflection at the top of the drilled shaft.
  - For guidance in the design of the drilled shafts (bearing capacity and lateral resistance), use FHWA-IF-99-025 *Drilled Shafts: Construction Procedures and Design Methods*, and the AASHTO *LRFD Bridge Design Specifications.*
  - Use the following properties in the design of the drilled shaft foundations:
    a. Two soil types (soft and stiff with the following parameters: Moist Unit Weight = 110 pcf
    b. Undrained shear strength, c = 500 psf (3.5 psi)
    c. Additional L-Pile parameters:
       i. Soil Type = Soft clay
       ii. k = 30 lb/in^3

iii. $\varepsilon_{50} = 0.02$
iv. Soil type = Stiff Clay—include water table depth = 3 ft.

F. MISCELLANEOUS

- Design all overhead signs to be illuminated. Overhead sign layout sheets will specify whether the sign is illuminated.
- Deflection and Camber
  Comply with the AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals", 2001 with interims.

14.2.3 CANTILEVER SIGN SUPPORTS

A. DEFINITIONS

Sign Height: The overall vertical dimension of the sign, including all supplementary panels.

Sign Area: The summation of the areas of all signs (actual or future) to be placed on the structure.

Nominal Post Height: The distance from the centerline of the horizontal mast arm to the bottom of base plate.

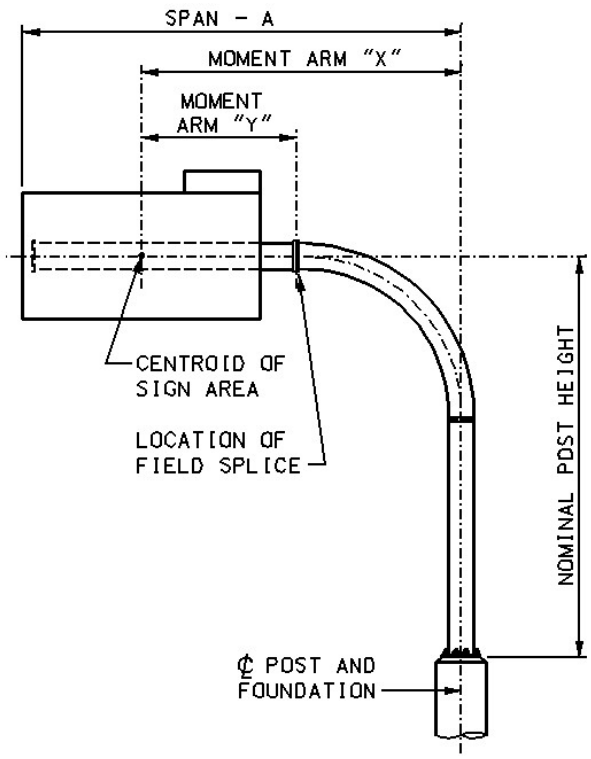
Exposure Factor, Kz: A dimensionless coefficient that corrects the magnitude of wind pressure referenced to a height above the ground of 30 ft for the variation of wind speed with height.

Moment-Arm "X": The distance from the centroid of the sign area and the centerline of the post and foundation.

Moment-Arm "Y": The distance from the centroid of the sign area and the field splice on the horizontal mast arm.

Moment-Area: The product of the sign area and the moment-arm defined above for the fatigue critical locations of either the field splice or the post base.

Span – A: The distance measured from the centerline of the post and drilled shaft foundation and the most distant end of the sign panel.



SCHEMATIC ELEVATION

B. UDOT STANDARD DESIGNS

The UDOT Standard Designs for Cantilever Sign Structures are provided for the use of structural designers for cantilever sign structures such that the resulting design values can be incorporated into the plan sets of any project to be advertised. Provide a custom design conforming to 14.2.2 if the design cannot meet the design parameters as indicated below:

- Maximum Nominal Post Height does not exceed 30'-0".
- The maximum span considered is 42'-6".
- 24" diameter tube sections or 30" diameter tube sections are supported by the standard designs.
- Minimum wall thickness for horizontal mast arms is 3/8".
- Minimum wall thickness for post and elbow is ½".
- Maximum wall thickness considered is ¾".
- Minimum Elbow Radius for 24" diameter tube sections is 8'-0"
- Minimum Elbow Radius for 30" diameter tube sections is 10'-0"

1. Use of UDOT Standard Designs

The standard design applies only to structures supporting plywood signs. These standard designs are expected to cover the great majority of sign structure requirements in Utah.

For sign structure requirements that do not meet the standard design parameters, provide a custom design. Prepare the custom design in accordance with the design criteria indicated above.

The UDOT Standard Designs are suitable for inclusion in the drawing packages as they are detailed. The structure designer determines whether the standard design is applicable to the cantilever sign structure required for the project and is responsible for preparing and sealing the drawings.

2. Limitations of Standard Designs

Use the Standard Design for sign structures supporting only standard plywood sign panels and their associated lighting, where required.

The limits shown for each structure in the tables or notes for span or arm length, total sign area, sign height and nominal post height cannot be exceeded using the standard designs. In addition, sign structures cannot be designed or selected by extrapolating beyond the limits of the tables. When any of these limits are exceeded, provide a custom design to support the structure requirements for the limit exceeded. A summary of the limitations for the structures contained in the tables follows.

- Maximum Nominal Post Height = 30 ft - all types
- Maximum Span – A = 42’-6”
- Maximum sign panel height, single mast arm type = 14 ft
- Maximum height of the centerline of the horizontal mast arm above surrounding terrain = 30 ft (height/exposure factor of 1.0).
- Maximum Moment-Area, single arm type – as tabulated in Table 14.2.3-1 below.

3. Sign Selection and Layout

Determine the size, type and location of sign panels to be supported by the sign structure. Evaluate whether future sign panel size increases are likely. If changes are expected, design the sign structure to accommodate the larger of either the current or future sign area. Determine the total sign area to be supported by the sign structure by summing all sign panel areas. Obtain approval from UDOT Traffic and Safety Division before finalizing sign panel configuration.

Based on the sign locations and sign areas, determine if a span or cantilever type sign structure is needed. Generally, cantilever structures should only be used to support signs over the shoulder or lane closest to the post. If the span, height, or Moment-Area exceeds the maximum tabulated values provide a custom design.

4. Design Procedures

The cantilever sign structure design procedures are outlined in the following sections. Select the pipe diameter, pipe wall thickness, splice plate connection and base plate requirements as indicated in the following sections. Select the foundation requirements based on the pipe diameter and the side slope requirements.

4.a. Nominal Post Height

Determine the nominal post heights (from the bottom of base plate to the centerline of the horizontal mast arm) by providing the required minimum vertical clearance of 17'-6" across the width of the entire roadway section beneath the sign structure. The vertical clearance envelope extends from the highest elevation of the roadway beneath the sign structure to the bottom of the sign panel(s) and all points on the sign structure including sign attachments, lighting and, if applicable, future anticipated sign panels and attachments. Horizontally, the clearance envelope extends to the roadside barrier

4.b. Sign Structure Number

The structure designer requests a UDOT Structure Number for all overhead sign structures from the UDOT Structures Division. UDOT Structures Division assigns one general structure number (G-###) for all sign structures of the same type on a project. Place the general structure number in the "DRG. NO." box of the title block. Provide one plan set for all cantilever sign structures on a project that apply to a general structure number. For more information about structure numbers, see Section 3.2.

4.c. Sign Structure Span or Mast Arm Length

Determine the required span length or cantilever arm length by locating the foundation and sign panels relative to the roadway.

4.d. Structure Type Selection

For cantilever sign structures with spans not exceeding 42'-6" and nominal post height not exceeding 30'-0", the structural tube wall thickness is governed by the fatigue stresses in the welds at the connections, such as the field splice plate and the post base plate. Therefore, the selection of the tube diameter and wall thickness is based on the moment-area product as shown in Table 1. The Moment-Area Threshold is the maximum value for which the diameter and wall thickness indicated is appropriate. Use the same diameter pipe for both the horizontal mast arm and post/elbow assembly. Do not use a pipe with wall thickness less than ½" for the post/elbow assembly. Note also

that economics of fabrication may also dictate a larger diameter pipe with a thinner wall. Verify the relative costs of the pipe selections with local fabricators before making a final selection.

NOMINAL PIPE DIAMETER, D (INCHES)	WALL THICKNESS (INCHES)	MOMENT-AREA THRESHOLD (FT^3)
24	0.375	2930
24	0.500	3870
30	0.375	4610
24	0.625	4780
24	0.750	5680
30	0.500	6100
30	0.625	7560
30	0.750	8990

Table 14.2.3-1

The elbow radius and camber for pipes of 24" and 30" diameter are indicated in Table 2.

NOMINAL PIPE DIAMETER, D (INCHES)	HEIGHT, B (FEET)	ELBOW RADIUS, R (FEET)	MAST ARM LENGTH, C (FEET)	CAMBER, T (INCHES)
24	$B \leq 30$	8	≤ 24.5	3.0
30	$B \leq 25$	10	≤ 32.5	3.5
30	$25 \leq B \leq 30$	10	≤ 32.5	4.0

Table 14.2.3-2

The field splice dimensions for pipes of 24" and 30" diameter are indicated in Table 3.

NOMINAL PIPE DIAMETER, D (INCHES)	PLATE DIAMETER, P (INCHES)	BOLT CIRCLE DIAMETER, Q (INCHES)	NUMBER OF BOLTS, N
24	35	30	24
30	41	36	30

Table 14.2.3-3

The base plate dimensions for pipes of 24" and 30" diameter tubes are indicated in Table 4.

NOMINAL PIPE DIAMETER, D (INCHES)	BASE PLATE DIAMETER, K (INCHES)	BOLT CIRCLE DIAMETER, L (INCHES)	NUMBER OF ANCHOR BOLTS, M
24	39	34	24
30	45	40	30

Table 14.2.3-4

4.e. Foundation Selection

The drilled shaft diameter and length requirements are summarized in Table 5.

NOMINAL PIPE DIAMETER, D (INCHES)	DRILLED SHAFT DIAMETER, G (INCHES)	PILE LENGTH, H, FOR VARIOUS GROUND SLOPES (FEET)				
		2:1	3:1	4:1 TO 6:1	8:1	>8:1
24	48	30	29	28	27	26
30	60	31	30	29	28	27

Table 14.2.3-5

The Drilled shaft reinforcing requirements are summarized in Table 6.

DRILLED SHAFT DIAMETER, G (INCHES)	VERTICAL REINFORCING BAR SIZE	NUMBER OF VERTICAL REINFORCING BARS
48	#8	24
60	#10	24

Table 14.2.3-6

5. Use of Electronic Standard Design Drawings

Electronic copies of the standard sheets are located on the UDOT Web site at http://www.sr.ex.state.ut.us/index.php/m=c/tid=1730. Incorporate the standard drawings into the advertisement set by completing the title block information as required for all other UDOT structures.

Prepare structure drawings in accordance with the following sheet-by-sheet instructions:
.

STANDARD DESIGN SHEET NUMBER	FINAL PLAN SET SHEET NUMBER	INSTRUCTIONS
1	1	Provide a location plan to show the structure with sufficient surrounding features of roadway, crossing streets and other structures on the project to locate the sign structure.
2	2-X	Provide an Elevation View that defines the relevant roadway geometrics, such as lane lines, barrier, barrier offsets, lane widths, side slopes and cross-slope. If multiple sign structures are to be incorporated into the advertisement set, provide an Elevation View for each sign location. Name these sheets ”G-###-X ELEVATION”. Both right side and left side cantilevers are shown on the standard design sheet. Show only the cantilevers that apply to the project.
3	X+1	Revise all alpha referenced dimensions to actual dimensions for a single sign structure in the project. If multiple sign structures make up part of the advertisement set, keep the alpha referenced dimensions and data and provide a tabulated summary of these data for the design
4	X+2	Revise all alpha referenced dimensions to actual dimensions for a single sign structure in the project. If multiple sign structures make up part of the advertisement set, keep the alpha referenced dimensions and data and provide a tabulated summary of these data for the design.
5	X+3	Show only the bracket plate detail(s) that correspond to the tube diameter for the sign structure specified. If both 24” diameter and 30” diameter tubes are specified, keep both bracket plate details in the plan set.
6	X+4	Complete the Sign Bracing Dimensions tabulation according to the actual sign dimensions that are supported on the cantilever sign structure(s) specified.
7	X+5	Use this sheet as is, unless a custom design is necessary. Adapt this sheet as needed to match the requirements of the custom design.
N/A	X+6	Add this sheet if multiple sign structures make up part of the advertisement set. This sheet consists of the tabulated data corresponding to the alpha referenced dimensions in the standard design drawings.

6. Custom Design Requirements

If the standard designs do not apply, provide a custom design for each cantilever sign structure adhering to the design criteria outlined in 14.2.2. If a custom design is required, provide full

analysis for the structure, including all connection details (welds, plates, bolts etc.) and foundations, to verify the structural adequacy of all structural elements.

If a custom design is required for the cantilever sign structures, include this item on the first sheet under Design Data: "CUSTOM DESIGN REQUIRED FOR STRUCTURE NO. G-###-X" and remove the item under Design Data "UDOT STANDARD DESIGN FOR CANTILEVER SIGN STRUCTURES".

C. REFERENCES

1. UDOT Standard Specifications for Road and Bridge Construction.

2. Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 4th Edition (2001) and its 2002 and 2003 Interims, published by AASHTO

3. NCHRP Report 412, Fatigue-Resistant Design of Cantilevered Signal, Sign and Light Supports, National Cooperative Highway Research Program, Transportation Research Board, National Research Council, 1998

14.2.4 SPAN-TYPE SIGN SUPPORTS

[Future Addition]

14.2.5 VARIABLE MESSAGE SIGN SUPPORTS

[Future Addition]

14.2.6 BUTTERFLY SIGN SUPPORTS

[Future Addition]

14.3 HIGH MAST LIGHT SUPPORTS

[Future Addition]

14.4 RETAINING WALLS

[Future Addition]

14.5 SOUND WALLS

[Future Addition]